Ingress and Spread of *Pseudomonas* in Stems of Peach and Apricot Promoted by Frost-Related Water-Soaking of Tissues

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ABSTRACT

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A freezing-thawing cycle created a water-soaked condition in the bark of shoots of peach and apricot that induced a quick (1 min) ingress and a noticeable spread (15–35 mm) of bacteria and dyes in tissues. This phenomenon may explain the decisive effect of low temperature on several diebacks and cankers of fruit trees caused by pseudomonads.

In severe peach dieback in France caused by *Pseudomonas syringae* pv. *persicae* (Prunier, Luisetti, and Gardan) Young, Dye, and Wilkie, low temperature has a decisive effect on infection development (9,10). Other diebacks caused by pseudomonads appear to behave similarly (4,7,11). Explanations of sugar content decrease (5) or bacterial ice nucleation (12) have been proposed but are not convincing. Freezing and thawing of the superficial tissues of sour cherry leaves have recently been reported to induce air displacement and the sucking of bacteria through stomata (8). In this paper, I propose that freezing and thawing cause the water-soaking of tissues that promotes the ingress and spread of *Pseudomonas* in fruit tree stems. This may initiate and favor extensive dieback.

During winter observations on peach and also on apricot (affected by *P. s.* pv. *syringae*), we noted that disease progress was especially pronounced after each period of slight frost (−3 C to −5 C), when stems appeared greasy and frozen. We also observed an association of the frozen appearance of peach tissues with disease development after artificial inoculations of excised dormant 1-yr-old shoots (9).

Many plants adapt to low temperatures (−1 C to −10 C) by transferring cellular water to intercellular spaces, where it freezes (2,6). In peach, the accumulation of ice between cells produces a frozen appearance (1). When the temperature rises and the ice thaws, continuous films of water form. The tissues remain water-soaked until the cells absorb the intercellular water. The phenomenon apparently recurs with each freezing period.

A water-soaked condition related to atmospheric high humidity or heavy rain has long been known to allow the ingress and spread of bacteria in tissues of many plants (3). We therefore sought to determine whether water-soaking related to freezing and thawing led to similar phenomena.

Six-month-old potted peach (*Prunus persica* (L.) Batsch 'GF 305') and apricot (*P. armeniaca* L. 'GF 1236') seedlings grown in an unheated (+10 C to +30 C) greenhouse were placed outdoors (+5 C to +12 C) for 1 wk. Five seedlings of each species were then moved to a refrigerated chamber for 24 hr at −4 C; the others were left outdoors. Two minutes after the refrigerated seedlings had been transferred to the laboratory (+20 C), the bark tissues began to thaw and the stems appeared water-soaked. They were paired with nonrefrigerated stems, and four or five internodes of each were superficially punctured (1 mm) with a needle. A 5-μl drop of erythrosin solution, black ink, or a suspension of *P. s.* pv. *persicae* (10^9 cells/ml) was then micropipetted on each puncture. Thin cortex samples of stems inoculated with *P. s.* pv. *persicae* were removed 1 min after drop deposition at 5-mm intervals from the puncture to evaluate spread of the pathogen through the tissues. In January, similar tests were performed with acclimated dormant 1-yr-old shoots of 6-yr-old peach trees (cv. Springtime) grown in an open field. Only ink was used, however, and the shoots had to be peeled to detect absorption and diffusion.

Only a very limited penetration of dyes and bacteria was observed with the control stems, whereas with different types of thawing stems, not only an ingress but a spread in the tissues was observed in a few seconds (Table 1).

Thus, water-soaking associated with thawing and that associated with other climatic conditions led to similar ingress and spread of bacteria or dyes in the tissues. No difference was noted in the behavior of the pathovar on the two tree species, confirming the mainly physical nature of the phenomenon. The thawing-

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Table 1. Effect of frost-related water-soaking on diffusion of black ink and bacteria in bark of peach and apricot stems

Plant materials	Diffusion indicator[a]	Unfrozen stems: Mean extent of diffusion[b] (mm)	Unfrozen stems: Range of values (mm)	Unfrozen stems: No. of measurements	Water-soaked stems after frost: Mean extent of diffusion[b] (mm)	Water-soaked stems after frost: Range of values (mm)	Water-soaked stems after frost: No. of measurements
Peach, 6-mo-old seedling stems	Black ink	1.2	1–2	15	21.3	7–25	19
	Bacterial suspension	1.5	1–5	8	24.4	15–35	11
Apricot, 6-mo-old seedling stems	Black ink	1	1	20	17.6	18–22	20
	Bacterial suspension	1	1	9	22.5	15–30	10
Peach, 1-yr-old acclimated dormant shoots	Black ink	3	2–4	38	11.5	4–22	36

[a] In 6-mo-old peach and apricot stems, diffusion of black ink was determined by direct observation through the epidermis and diffusion of bacterial suspension was determined by germ isolation every 5 mm from the entry point. In 1-yr-old peach shoots, diffusion was determined by observation after peeling the superficial opaque tissues.

[b] Longest of the two directions of diffusion, observed 1 or 2 min after deposition of the indicator.

mediated ingress of inoculum promotes a massive inoculation in which potentially larger pathogen populations become deposited in ideal infection courts. This may explain infections initiated in peach and apricot orchards by winter pruning wounds; we found such infections to be especially severe when pruning was done just before a frost period. In addition, the trend of canker spread in orchards and late canker appearance around contaminated leaf scars, both related with low temperature events (10), suggest that the thawing-related water congestion may be responsible for the resurgence of latent internal populations or for the promotion of expansion of existing cankers. We are currently studying this aspect.

LITERATURE CITED

1. Ashworth, E. N., Anderson, J. A., Davis, G. A., and Lightner, G. W. 1985. Ice formation in *Prunus persica* under field conditions. J. Am. Soc. Hortic. Sci. 110:322-324.
2. Burke, M. G., Gusta, L. V., Quamme, M. A., Weiser, C. J., and Li, P. H. 1976. Freezing and injury in plants. Annu. Rev. Plant Physiol. 27:507-528.
3. Johnson, J. 1945. Infection experiments with detached water congested leaves. Phytopathology 35:1017-1028.
4. Klement, Z., Rozsnyay, D. S., and Arsenijevic, M. 1974. II. Relationship of winter frost and the bacterial canker and dieback of apricots. Acta Phytopathol. Acad. Sci. Hung. 9:35-45.
5. Klement, Z., Rozsnyay, D. S., Balo, E., Panczel, M., and Prileszky, G. 1984. The effect of cold on development of bacterial canker in apricot trees. Physiol. Plant Pathol. 24:237-246.
6. Olien, C. R. 1967. Freezing stresses and survival of plants. Annu. Rev. Plant Physiol. 18:387-408.
7. Panagopoulos, C. G., and Crosse, J. E. 1964. Frost injury as a predisposing factor in blossom blight of pear caused by *Pseudomonas syringae* Van Hall. Nature 202:1352.
8. Sule, S., and Seemuller, E. 1987. The role of ice formation in the infection of sour cherry leaves by *Pseudomonas syringae* pv. *syringae*. Phytopathology 77:173-177.
9. Vigouroux, A. 1974. Obtention de symptomes de bacteriose du Pêcher sur rameaux de pecher detachés. Effets du froid. Ann. Phytopathol. 6:95-98.
10. Vigouroux, A. 1979. Incidence des basses temperatures sur la sensibilité du Pêcher au deperissement bacterien. Ann. Phytopathol. 11:231-239.
11. Weaver, D. J. 1978. Interaction of *Pseudomonas syringae* and freezing in bacterial canker on excised peach twigs. Phytopathology 68:1460-1463.
12. Weaver, D. J., Gonzales, C. F., and English, H. 1981. Ice nucleation by *Pseudomonas syringae* associated with canker production in peach. (Abstr.) Phytopathology 71:109.